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ORIGINAL ARTICLE

Factors associated with dengue cases in brazilian industrial area: an ecological study

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Abstract

Introduction: Dengue is an acute systemic viral infectious disease, established worldwide in epidemic and endemic transmission cycles. High levels of precipitation, adequate temperatures, proximity between urban and peri-urban centers, human movement between population centers and urban solid waste (USW) production may facilitate dengue transmission and spread.

Objective: To identify the relationship between diagnosed dengue cases and socioeconomic factors, USW mass generation and rainfall index.

Methods: Ecological study, with secondary data collection from 2010 to 2016 for each municipality of the Greater ABC Region in São Paulo, Brazil. Total population, gross domestic product (GDP) per capita, USW, number of dengue cases and rainfall index were investigated. Data were collected on the websites of the Brazilian Institute of Geography and Statistics (IBGE), the municipalities of the Greater ABC Region, the Greater ABC Intermunicipal Consortium, the Greater ABC Economic Development Agency, the National Sanitation Information System, Surveillance Epidemiological Survey of the State of São Paulo and the Department of Water and Electric Energy of the State of São Paulo. Relationships between variables were tested by Spearman correlation.

Results: Data analysis of all municipalities showed a positive correlation between dengue cases with total population ($r=0.675$, $p<0.01$), gross domestic product per capita ($r=0.539$, $p<0.01$) and MSW by inhabitant per year ($r=0.492$, $p<0.01$). Positive correlations were also observed between total population and gross domestic product per capita ($r=0.583$, $p<0.01$), MSW / Day ($r=0.302$, $p<0.05$) and MSW/year ($r=0.961$, $p<0.01$); gross domestic product per capita and MSW/day ($r=0.849$, $p<0.01$), MSW/year ($r=0.410$, $p<0.05$) and rainfall index (RI) ($r=0.416$, $p<0.05$); MSW / day and MSW / year ($r=0.389$, $p<0.01$) and RI ($r=0.388$, $p<0.05$).

Conclusion: The larger the total population, purchasing power or socioeconomic status (GDP per capita) and the generation of MSW, the greater the number of dengue cases. Proper packaging of MSW seems to be a way to help in dengue cases control.

Keywords: dengue, dengue virus, socioeconomic factors, solid waste.

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Authors summary

Why was this study done?
To identify the relationship between diagnosed dengue cases and socioeconomic factors, mass generation of solid urban waste and rainfall.

What did the researchers do and find?
A study was carried out with secondary data collection from 2010 to 2016 for each municipality in the Greater ABC Region, in São Paulo, Brazil. Information on total population, gross domestic product (GDP) per inhabitant, number of dengue cases, rainfall index, urban waste per municipality kg \ day and Urban Solid Waste ton / month were collected.

What do these findings mean?
The larger the total population, the greater the purchasing power or socioeconomic status (GDP per capita) and the generation of MSW, the greater the number of dengue cases. Proper disposal of solid urban waste is a way to help control dengue cases.

INTRODUCTION

Dengue is an acute systemic viral disease that has been established worldwide in epidemic and endemic transmission cycles in Bhatt *et al.*[1]. Between 1990 and 2013, approximately 9221 dengue deaths were estimated per year Stanaway *et al.*[2]. The incidence of dengue presented a great increase in this period. Dengue cases has almost doubled every decade, from 8.3 million cases in 1990 to 58.4 million cases in 2013 Stanaway *et al.*[2]. Dengue is an infectious disease caused by RNA genome virus and the serotypes are commonly called dengue type 1, type 2, type 3 and type 4 according to the FUNASA[3]. This disease is characterized by both variable fever, clinically classified as dengue fever (FD) or classical dengue, and severe manifestations such as hemorrhage, dengue hemorrhagic fever (DHF), and dengue shock syndrome (SCD), may leading to death[3].

The main vector of the dengue virus is the Aedes aegypt mosquito, which is adapted to the domestic environment and associated with demographic growth, as well as national and international exchanges. These factors plus variations in rainfall index, humidity and temperature in the environment increase mosquito dispersal and spread of viral serotypes, as human populations have receptive containers for vector reproduction such as standing water in tires and vases according to the Donalísio and Glasser[4]. Dengue transmission peak may be related to increased survival of the adult vector, under conditions of temperature and humidity of the rainy season and not its density. The longer mosquito survival enables the infected females to complete the virus replication period in Glasser and Gomes[5].

Areas with high levels of precipitation and adequate temperatures are strongly associated with high risks of dengue Bhatt *et al.*[1]. In addition, the proximity between urban areas and peri-urban centers (*i.e.* peripheral regions in large cities with low income and high quantity of people with unsatisfactory hygiene and sanitation conditions) is also associated with high risks of dengue, especially in highly interconnected areas[1].

This indicates that human movement between population centers is a facilitator of dengue transmission and spread Bhatt *et al.*[1] and Carneiro *et al.*[6].

Waste management can be an effective and sustainable dengue vector control strategy Abeyewickreme *et al.*[7]. Solid waste can be defined as any material, substance, object or good discarded as a result of human activities in society, whose final destination is made, proposed to proceed or is required to proceed, in the solid or semi-solid state, as well as gases. Contained in containers and liquids the particularities of which make it impossible for them to be discharged into the public sewage system or bodies of water or to require technically or economically unviable solutions in the face of the best available technology. Solids waste are grouped in Urban Solid Waste (USW) and classified according to the origin as follows: Domestic Solid Waste, originated from domestic activities in urban residences; or Public Solid Waste, originated from sweeping, street and street cleaning and other urban cleaning services according the Ministério do Meio Ambiente em 2010[8].

The objective of the study is to identify the relationship between the diagnosed cases of dengue and socioeconomic factors, USW mass generation and rainfall index in Brazilian industrial area, from 2010 to 2016.

METHODS

This study is an ecological study, with secondary data collection. Data collection occurred between 2016 and 2017 and the data refer to the years 2010 to 2016 for each municipality of the Greater ABC Region. Seven municipalities comprise this region: Santo André, Sao Caetano do Sul, Sao Bernardo do Campo, Diadema, Mauá, Ribeirão Pires and Rio Grande da Serra. The variables investigated were total population, gross domestic product (GDP) per capita, Urban Solid Waste (USW), number of dengue cases and rainfall index. The Greater ABC Region is composed of seven municipalities (Santo André, Sao Caetano do Sul, Sao Bernardo do Campo, Diadema, Mauá, Ribeirão Pires and Rio Grande da Serra) in the southeast of São Paulo city, and conciliates the presence of important industrial complexes, high degree of urbanization, and also green spaces and environmental preservation, whose water production is an important part of the metropolitan supply system.

Study Variables

Total population refers to annual population estimates made by IBGE and, in the present study, total population estimates (sum of municipalities) were used from 2010 to 2016 and by each municipality investigated. GDP per capita is defined as the division of the current value of GDP by the mid-year resident population[9].

MSW comprises the grouping of Domestic Solid Waste, originating from domestic activities in urban residences, and Public Solid Waste, originating from sweeping, street and street cleaning and other urban cleaning services[8]. In the present study, the USW in kilograms per inhabitant per day (Kg / Hab / Day) and the total weight of the ton were used. USW in Kg / Hab / Day is defined by the formula shown in Figure 1. For this index, a calculation is made of the mass collected, ie the sum of household and commercial solid waste (RDO) and public solid waste (RPU) per capita in relation to the total urban population served by the collection service according the SNIS[10].

$$\frac{CO116 + CO117 + CS048 + CO142}{CO164} \times \frac{1.000}{365}$$

Figure 1: Indicator number 28 - Mass collected per capita in relation to the total urban population served by the collection service. Source: Glossary of Indicators - Solid Waste - Expenditure and Worker Indicators (SNIS 2018).

CO116: Amount of RDO and RPU collected by public agent

CO117: Quantity of RDO and SPS collected by private agents

CO142: Amount of RDO and RPU collected by other executing agents

CO164: Total population served in the municipality

CS048: Amount collected from selective collection performed by collectors or cooperatives of collectors with partnership / support from City Hall

The number of dengue cases is defined by all laboratory-confirmed suspected dengue cases (IgM serology, NS1, viral isolation, PCR, immunohistochemistry). After laboratory verification of viral circulation in the researched area, confirmation is made by clinical and epidemiological criteria[3].

Finally, the rainfall index is the quantification of water precipitation (rain, hail) measured in milliliters and we used the annual rainfall index.

Instruments

We used secondary sources of database. The characterization of municipalities (population and GDP per capita) and information from the last census of the Human Development Index (HDI) were obtained by consulting the website of the Brazilian Institute of Geography and Statistics (IBGE)[9]. All other data about the municipalities were searched on the following websites: the Greater ABC Region (André 2018)[11], (Sao Caetano do Sul 2018)[12], (Sao Bernardo do Campo 2018)[13], (Diadema 2018)[14], (Mauá 2018)[15], (Ribeirão Pires 2018)[16] and (Rio Grande da Serra 2018)[17]; the Greater ABC Intermunicipal Consortium[18] and the Greater ABC Economic Development Agency 2012[19].

Waste management data were obtained from the National Sanitation Information System Report, entitled Diagnosis of Urban Solid Waste Management (SNIS)[10]. Dengue case data were obtained from the São Paulo State Epidemiological Surveillance website20. The information on rainfall index in each municipality, except for Rio Grande da Serra (not available), was obtained from the Hydrological database at the Department of Water and Electricity of São Paulo (DAEE)[21].

Statistical analysis

Excel 2013 programs were used for database elaboration and Statistical Package for Social Research (SPSS) version 22.0 for statistical analysis. Data were plotted and distributed in simple frequency table, expressed in absolute numbers. The Shapiro-Wilk test was used to verify data normality. The variables were non-parametric, and the statistical correlation test used was Spearman. We used a significance level of 0.05 (5%) with 95% confidence intervals.

RESULTS

All municipalities in the Greater ABC Region between 2010 and 2016 were analyzed. Absolute values of total population, GDP per capita, USW collected per day and per year, diagnosed cases of dengue, rainfall index and HDI for all cities are presented in Table 1. The total population increased each year during this seven-year period in all municipalities. In Santo André, Sao Bernardo do Campo and Sao Caetano do Sul, GDP per Capita annually decreased. The production of MSW / day and MSW/year shows a decrease in all municipalities in the analyzed period. In 2015, Diadema, Santo André and São Bernardo do Campo showed a large increase in dengue cases compared to previous years.

Table 1: Total population, Gross Domestic Product per capita, Municipal solid waste collected per day, Urban solid waste per year, Dengue cases, Rainfall Index and HDI for all cities present in this study between 2010 and 2016.

	Total Population	GDB per capita	USW/ Day	USW/ year	Dengue cases	IP	HDI
Diadema							0.757
2010	386.039	27.716,85	0,84	118.779,00	177	2144,5	
2011	388.576	30.015,43	0,82	116.977,00	295	966,4	
2012	390.980	30.687,72	0,83	117.928,00	26	1619,5	
2013	406.718	32.556,89	0,79	117.703,00	77	1333	
2014	409.613	34.296,61	0,79	118.067,0	432	1042,5	
2015	412.428	33.592,70	0,78	118.115,0	2714	1477,8	

Continuation - Table 1: Total population, Gross Domestic Product per capita, Municipal solid waste collected per day, Urban solid waste per year, Dengue cases, Rainfall Index and HDI for all cities present in this study between 2010 and 2016.

	Total Population	GDB per capita	USW/ Day	USW/ year	Dengue cases	IP	HDI
2016	415.180	NI	0,75	113.030,0	471	1155,6	
Total	2.809.534	188.866	6	820.599	4.192	9.739	
Mauá							0.766
2010	444.136	22.343,28	0,86	131.067,00	21	662,4	
2011	421.184	23.298,86	0,79	121.624,30	19	333,3	
2012	425.169	21.862,74	0,79	121.921,90	12	352,6	
2013	444.136	23.639,95	0,75	122.059,00	16	575,1	
2014	448.776	24.947,60	0,74	120.471,6	56	507,9	
2015	453.286	27.421,26	0,72	119.750,4	421	1039,6	
2016	457.696	NI	0,70	117.106,0	407	1011,5	
Total	3.094.383	143.514	5	854.000	952	4.482	
Ribeirão Pires							0.784
2010	113.043	15.956,76	0	55.588,30	7	914,1	
2011	113.726	17.814,10	0,71	29.379,80	1	816,3	
2012	114.361	19.345,71	0,8	33.480,00	2	1119,8	
2013	118.871	21.616,67	0,74	31.970,80	3	610,3	
2014	119.664	22.922,43	0,74	32.339,3	16	481,2	
2015	120.396	23.368,18	0,85	37.400,70	21	578,3	
2016	121.130	NI	0,52	22.900,80	14	452,1	
Total	821.191	121.024	4	243.060	64	4.972	
Rio Grande da Serra							0.749
2010	44.084	8.722,33	NI	NI	3	NI	
2011	44.503	9.551,40	NI	NI	3	NI	
2012	45.014	10.041,13	NI	NI	0	NI	
2013	47.142	11.236,99	NI	NI	3	NI	
2014	47.731	10.903,94	0,57	7.562,0	4	0	
2015	48.302	11.039,99	0,56	7.562,4	0	0	
2016	48.861	NI	0,56	8.035,5	2	0	
Total	325.637	61.496	2	23.160	15	0	
Santo André							0.815
2010	673.900	28.437,62	0,91	224.003,00	180	1275,6	
2011	678.486	32.043,18	0,92	226.678,00	71	682,4	
2012	680.496	35.037,66	0,95	234.375,90	40	1823,8	
2013	704.942	37.906,32	0,87	223.877,50	106	1548,3	
2014	707.613	37.791,08	0,86	222.105,0	383	636,8	
2015	710.210	36.948,06	0,90	232.814,0	1383	600,1	
2016	712.749	NI	0,83	214.939,0	378	624,7	
Total	4.868.396	208.164	6	1.578.792	2.541	7.192	
São Bernardo do Campo							0.805
2010	810.203	55.615,87	NI	251.584,20	158	1391,9	
2011	770.253	60.357,30	0,94	263.994,40	158	893,4	
2012	774.886	58.460,99	0,94	266.409,60	36	1417,8	

Continuation - Table 1: Total population, Gross Domestic Product per capita, Municipal solid waste collected per day, Urban solid waste per year, Dengue cases, Rainfall Index and HDI for all cities present in this study between 2010 and 2016.

	Total Population	GDB per capita	USW/ Day	USW/ year	Dengue cases	IP	HDI
2013	805.895	60.540,53	0,9	264.221,20	170	1061,5	
2014	811.489	58.492,19	0,90	265.459,9	606	669,1	
2015	816.925	52.324,92	0,91	271.774,8	2828	1065,2	
2016	822.242	NI	0,83	246.791,2	1222	767,5	
Total	5.611.893	345.792	5	1.830.235	5.178	7.266	
São Caetano do Sul							0.862
2010	149.295	81.600,94	1,34	73.131,00	31	1355	
2011	149.962	88.554,07	1,53	83.735,00	30	826,6	
2012	150.638	100.204,28	1,51	82.827,00	9	1306,1	
2013	156.362	102.024,95	1,13	64.697,00	27	1036,3	
2014	157.205	98.811,07	1,11	63.507,8	82	987,3	
2015	158.024	84.177,85	1,06	61.368,8	348	1541,2	
2016	158.825	NI	1,06	61.731,8	104	1070	
Total	1.080.311	555.373	9	490.998	631	8.123	
All cities	18.611.345	1.624.228,40	37,4	5.840.844,90	13573	41774,4	

Gross Domestic Product (GDP); Municipal solid waste collected per capita in relation to the total population served Kg / Hab / Day (USW / Day); Human Development Index (HDI); Tons of municipal solid waste in the year (USW/ Year); Rainfall index (RI); NI: not informed;

The table 2 presents the results of diagnosed dengue cases correlated with socioeconomic factors, USW mass generation and rainfall index in the Greater ABC region, from 2010 to 2016. In the Greater ABC Region (all seven municipalities analyzed as one major region), dengue cases were positively and significantly correlated with the total population, GDP per capita and MSW mass generation per inhabitant per year. In addition, according to Spearman's test, there was a positive correlation between: total population with GDP per capita, USW per day and USW per year; GDP per capita with USW per day, USW per year and IP; and USW per day with IP and USW per year.

Table 2: Correlation between Total Population, Gross Domestic Product per capita, Municipal Solid Waste collected per capita per day, Municipal Solid Waste per year, Dengue Cases and Rainfall Index for all cities present in this study between 2010 and 2016.

	Total population	GDP per capita	USW day	USW year	Dengue cases	IP
All cities						
Total population	-	0.583**	0.302*	0.961**	0.675**	0.059
GDP per capita	0.583**	-	0.849**	0.410*	0.539**	0.416*
USW day	0.302*	0.849**	-	0.389**	0.129	0.388*
USW year	0.961**	0.410*	0.389**	-	0.492**	0.108
Dengue cases	0.675**	0.539**	0.129	0.492**	-	0.261
RI	0.059	0.416*	0.388*	0.108	0.261	-
DIADEMA						
Total population	-	0.943**	-0.955**	-0.321	0.679	-0.286
GDP per capita	0.943**	-	-0.841*	0.029	0.486	-0.371
USW day	-0.955**	-0.841*	-	0.432	-0.739	0.432
USW year	-0.321	0.029	0.432	-	0.000	0.643
Dengue cases	0.679	0.486	-0.739	0.000	-	-0.357
RI	-0.286	-0.371	0.432	0.643	-0.357	-
MAUÁ						
Total population	0.000	0.783	-.0836*	-0.667	0.829*	0.847*

Continuation - Table 2: Correlation between Total Population, Gross Domestic Product per capita, Municipal Solid Waste collected per capita per day, Municipal Solid Waste per year, Dengue Cases and Rainfall Index for all cities present in this study between 2010 and 2016.

	Total population	GDP per capita	USW day	USW year	Dengue cases	IP
GDP per capita	0.783	-	-0.899*	-0.714	0.771	0.486
USW day	-0.836*	-0.899*	-	0.883**	-0.685	-0.559
USW year	-0.667	-0.714	0.883**	-	-0.714	-0.357
Dengue cases	0.829*	0.771	-0.685	-0.714	-	0.750
RI	0.847*	0.486	-0.559	-0.357	0.750	-
RIBEIRÃO PIRES						
População Total	-	1.000**	-0.058	-0.393	0.679	-0.857*
GDP per capita	1.000**	-	0.667	-0.029	0.657	-0.771
RSU/Dia	-0.058	0.667	-	0.986**	0.377	0.377
RSU/Ano	-0.393	-0.029	0.986**	-	0.286	0.500
Casos de Dengue	0.679	0.657	0.377	0.286	-	-0.679
RI	-0.857*	-0.771	0.377	0.500	-0.679	-
RIO GRANDE DA SERRA						
Total population	-	0.829*	-0.866	1.000**	0.185	#
GDP per capita	0.829*	-	-1.000**	1.000**	0.395	#
USW day	-0.866	-1.000**	-	-0.866	0.000	#
USW year	1.000**	1.000**	-0.866	-	-0.500	#
Dengue cases	0.185	0.395	0.000	-0.500	-	#
RI	#	#	#	#	#	#
SANTO ANDRÉ						
Total population	-	0.771	-0.750	-0.429	0.643	-0.679
GDP per capita	0.771	-	-0.714	-0.429	0.257	-0.086
USW day	-0.750	-0.714	-	0.893**	-0.679	0.571
USW year	-0.429	-0.429	0.893**	-	-0.393	0.321
Dengue cases	0.643	0.257	-0.679	-0.393	-	-0.857*
RI	-0.679	-0.086	0.571	0.321	-0.857*	-
SÃO BERNARDO DO CAMPO						
Total population	-	-0.600	-0.794	-0.107	0.847*	-0.357
GDP per capita	-0.600	-	-0.316	-0.371	-0.174	-0.543
USW day	-0.794	-0.316	-	0.441	-0.618	0.618
USW year	-0.107	-0.371	0.441	-	0.090	0.321
Dengue cases	0.847*	-0.174	-0.618	0.090	-	-0.523
RI	-0.357	-0.543	0.618	0.321	-0.523	-
SÃO CAETANO DO SUL						
Total population	-	0.257	-.883**	-.857*	0.643	0.107
GDP per capita	0.257	-	0.086	0.086	-0.657	-0.429
USW day	-.883**	0.086	-	.991**	-.811*	-0.378
USW year	-.857*	0.086	.991**	-	-.821*	-0.429
Dengue cases	0.643	-0.657	-.811*	-.821*	-	0.321
RI	0.107	-0.429	-0.378	-0.429	0.321	-

Spearman correlation; Gross Domestic Product (GDP); Municipal solid waste collected per capita in relation to the total population served Kg / Hab / Day (USW / Day); Tons of municipal solid waste in the year (USW/ Year); Rainfall index (RI); ** Correlation is significant at level 0.01; * Correlation is significant at level 0.05.

In the municipality of Diadema, no statistically significant correlations were found between dengue cases and the factors analyzed. GDP per capita was correlated with the total population and inversely correlated with USWper day. In Mauá, dengue cases were positively correlated with the total population, with no significant correlation with the other factors analyzed. In this municipality, USW per day was inversely correlated with total population and GDP per capita, and directly correlated with USW per year. The RI was directly correlated with the total population of Mauá. In Ribeirão Pires, there was no significant correlation between the analyzed parameters and dengue cases. There was, however, a positive correlation between total population and GDP per capita, and USW per year and USW per day. RI was inversely correlated with total population.

Table 2 also shows that, according to Spearman's correlation test, dengue cases do not correlate with the parameters studied in the municipality of Rio Grande da Serra. The correlation of the parameters with the RI was not calculated because the municipality does not provide rainfall index data for each year. USW per year was directly correlated with total population and GDP per capita, while USW per day was inversely correlated with total population. In Santo André, the results showed that dengue cases were inversely correlated with RI. In São Bernardo do Campo, it was found that dengue cases correlated inversely with the total population. Dengue cases were inversely correlated with MSW per year and per day in the municipality of São Caetano do Sul. The other correlations that occurred were indirect between total population and USW per day and per year.

There was no correlation between population ($p = 0.337$), number of dengue cases ($p = 0.294$) and human development index (HDI), except for GDP per capita ($p = 0.023$ with a correlation coefficient of 0.821).

DISCUSSION

The present study analyzed the relationship between the diagnosed cases of dengue and the socioeconomic factors, USW mass generation and rainfall index in the Greater ABC region and its municipalities, from 2010 to 2016. It was found that in the Greater Region of ABC, the diagnosed cases of dengue were correlated with the total population, the GDP per capita and the generation of waste collected per inhabitant per year. These results suggest that the larger the total population, purchasing power or socioeconomic status (GDP per capita) and the generation of urban solid waste, the greater the number of dengue cases. Analysis by each municipality revealed that in Mauá, dengue cases were positively correlated with the total population, while in São Bernardo do Campo, this correlation was inverse. In Santo André, an inverse correlation was found between dengue and RI cases. In São Caetano do Sul, the production of solid waste per year and per day per inhabitant were inversely correlated with dengue cases. In the municipalities of Ribeirão Pires, Rio Grande da Serra and Diadema there was no correlation of dengue cases with the factors analyzed.

There is sufficient evidence to argue that dengue is more likely to be influenced by a complex combination of factors rather than a single pathogenic factor, including environmental, demographic, entomological, and epidemiological factors Yue *et al.*[22], Udayanga *et al.*[23], Udayanga *et al.*[24]. The various spheres of government have directed efforts in raising awareness among the population to reduce mosquito breeding, such as the elimination of standing water. However, vector control and prevention programs are often insufficient, ineffective or both How do you say Guzman *et al.*[25]. This is due in part to the fact that the dengue vector, Aedes aegypti, has a great adaptability and can reproduce even in polluted waters and at high altitudes Thammapalo *et al.*[26].

Our results demonstrated significant correlation between increase dengue cases and total population in the municipality of Mauá. Human density may be critical for the spread of the disease, particularly in urban landscapes Romeo-Aznar *et al.*[27]. Diadema, Ribeirão Pires and Rio Grande da Serra showed no correlation between cases of dengue and other factors. These could be due to individuals infected may register the disease in other municipalities specially because the greater facility to health care units, indigenous or imported[19]. According to ten Bosh[28], most dengue infections are clinically asymptomatic and inapparent infections can contribute significantly to the burden of disease in endemic area.

In the municipality of Santo André, there was no significance of the studied parameters with dengue cases, except for the RI, inversely correlated with dengue cases. Contrary to our results, a study in other Brazilian metropolitan area showed the total amount of rainfall was significantly associated with the number of dengue incidences according Santos *et al.*[29] . Focks & Barrera[30] and Patz *et al.*[31] stated that vector density increases due to rain, causing an increase in dengue cases, because the higher humidity during the rainy season provides an ideal environment for growth and survival of dengue fever mosquitoes. In this study, there was no association between rainfall index and dengue cases. This may lead us to suppose that non-climatic factors can directly influence dengue cases in the Greater ABC Region.

The increase in dengue cases was directly related to the generation of USW and GDP per capita, i.e., the higher the purchasing power, the higher was the consumption and, consequently, the greater was the production of waste. With a population[19] of 827 km^2, the Greater ABC Region currently stands out for its variety of production chains, increasing participation in service sector activities and increased retail trade, representing one of the largest consumer markets in the country. The higher the production of urban solid waste per day and year in São Caetano do Sul, the lower the number of dengue cases. This result may be due to the municipal waste being collected daily. The existence of waste containers near homes is associated with a high incidence of dengue Gama *et al.*[32] and the lower the region's GDP, the higher the incidence of dengue cases Qu *et al.*[33]. In a recent study, the economic impact on the control of mosquito-borne diseases was demonstrated, revealing that the epidemiology of dengue has reduced the country's gross annual income (ie Maldives) by $ 110 per resident Bangert *et al.*[34].

Considering the characteristics of each municipality analyzed, a large portion of the population lives in areas that are difficult to access, and although collection is provided in 100% of the area, 100% of the waste generated may not be collected Franca *et al*.[35], consequently there may be accumulation of waste in inappropriate places and accumulate water, facilitating the proliferation of *Aedes Aegypti*. Another important feature is the presence of spaces and nature reserves for environmental preservation, which is approximately 50% of the territory, being one of the main reservoirs of water and nature reserve in the State of São Paulo[20]. A study in North Queensland, Australia found that containers with abundant organic matter tended to produce a larger, rapidly developing adult mosquito Thammapalo *et al*.[26]. In this context, the assumption that household waste influences population volume is strong, not only because of the existence of breeding sites, but because it provides a food supply demanded by the mosquito throughout its life cycle. Studies have already shown that there is a large volume of positive breeding sites from domestic waste Zara *et al*.[36], which generates the need for attention on the importance of proper waste packaging Souza-Santos[37]. However, as important as the proper disposal of waste is efficient and regular collection, since it is directly related to the control of *Aedes aegypti Lefèvre et al*.[38]. Studies have highlighted the importance of improving education and garbage collection in reducing cases[23,24].

Future studies should investigate the relationship of dengue cases with other factors such as change in urbanization / land use status, vector control and personal protection program (housing quality), and incorrect waste disposal and storage.

In Brazilian industrial area, diagnosed dengue cases were related to the total population, GDP per capita and waste generation per year, with no relationship between dengue cases and rainfall index, human development index and collected urban solid waste per day. The results of the present study suggest that the correct packaging of residues may be a way to help control dengue cases.

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Resumo

Introdução: A dengue é uma doença infecciosa viral sistêmica aguda, estabelecida mundialmente em ciclos de transmissão epidêmica e endêmica. Altos níveis de precipitação, temperaturas adequadas, proximidade entre centros urbanos e peri-urbanos, movimento humano entre centros populacionais e produção de resíduos sólidos urbanos (RSU) podem facilitar a transmissão e a disseminação da dengue.

Objetivo: Identificar a relação entre casos diagnosticados de dengue e fatores socioeconômicos, geração de massa de RSU e índice pluviométrico.

Método: Estudo ecológico, com coleta secundária de dados de 2010 a 2016 para cada município da Região do Grande do ABC, em São Paulo, Brasil. Foram investigados a população total, o produto interno bruto (PIB) per capita, RSU, número de casos de dengue e índice pluviométrico. Os dados foram coletados nos sites do Instituto Brasileiro de Geografia e Estatística (IBGE), os municípios da Região do Grande ABC, o Consórcio Intermunicipal do Grande ABC, a Agência de Desenvolvimento Econômico do Grande ABC, o Sistema Nacional de Informação sobre Saneamento, Centro de Vigilância Epidemiológica do Estado de São Paulo e o Departamento de Água e Energia Elétrica do Estado de São Paulo. As relações entre variáveis foram testadas pela correlação de Spearman.

Resultados: A análise dos dados de todos os municípios mostrou correlação positiva entre casos de dengue com população total ($r = 0,675$, $p < 0,01$), produto interno bruto per capita ($r = 0,539$, $p < 0,01$) e RSU por habitante por ano ($r = 0,492$, $p < 0,01$). Também foram observadas correlações positivas entre população total e produto interno bruto per capita ($r = 0,583$, $p < 0,01$), RSU / dia ($r = 0,302$, $p < 0,05$) e RSU / ano ($r = 0,961$, $p < 0,01$); produto interno bruto per capita e RSU / dia ($r = 0,849$, $p < 0,01$), RSU / ano ($r = 0,410$, $p < 0,05$) e índice de precipitação (IR) ($r = 0,416$, $p < 0,05$); RSU / dia e RSU / ano ($r = 0,389$, $p < 0,01$) e IR ($r = 0,388$, $p < 0,05$).

Conclusão: Quanto maior a população total, poder de compra ou condição socioeconômica (PIB per capita) e a geração de RSU, maior o número de casos de dengue. O descarte adequada dos RSU parece ser uma maneira de ajudar no controle dos casos de dengue.

Palavras-chave: dengue, vírus da dengue, fatores socioeconômicos, resíduos sólidos.